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GB 1327003
GB 1112390
GB 1087798
GB 0936861
GB 0735147
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(54) Water-jet steering mechanism

(57) A steering mechanism for a water-jet propelled craft having a rotatable propulsion nozzle 12 comprises a fine steering control 18 and a coarse reversal control 21. The controls 18 and 21 rotate the nozzle 12 via a differential gearbox 14 consisting of four meshed bevel gears rotatable in bearings within a gear cage 20. The steering control 18 is operative to rotate a gearbox input shaft 15 via a worm and pinion reduction gear 16 and 17, and the reversal control 21 is operative to rotate the cage 14. The nozzle 12 is connected to a gearbox output shaft 13. The reduction gear 16 and 17 inhibits torque feedback from the reversal control 21 to the steering control 18, and torque feedback from the steering control 18 to the reversal control 21 is inhibited by hydraulic ram actuation of the reversal control 21.

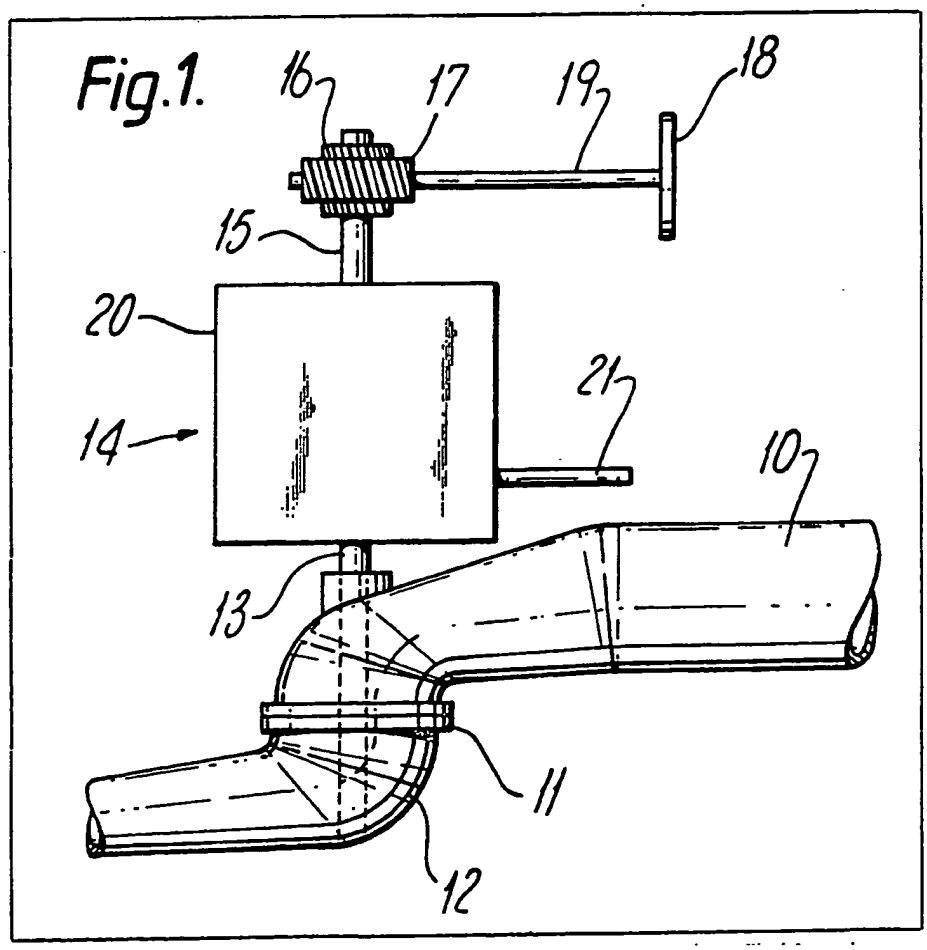

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Fig.1.

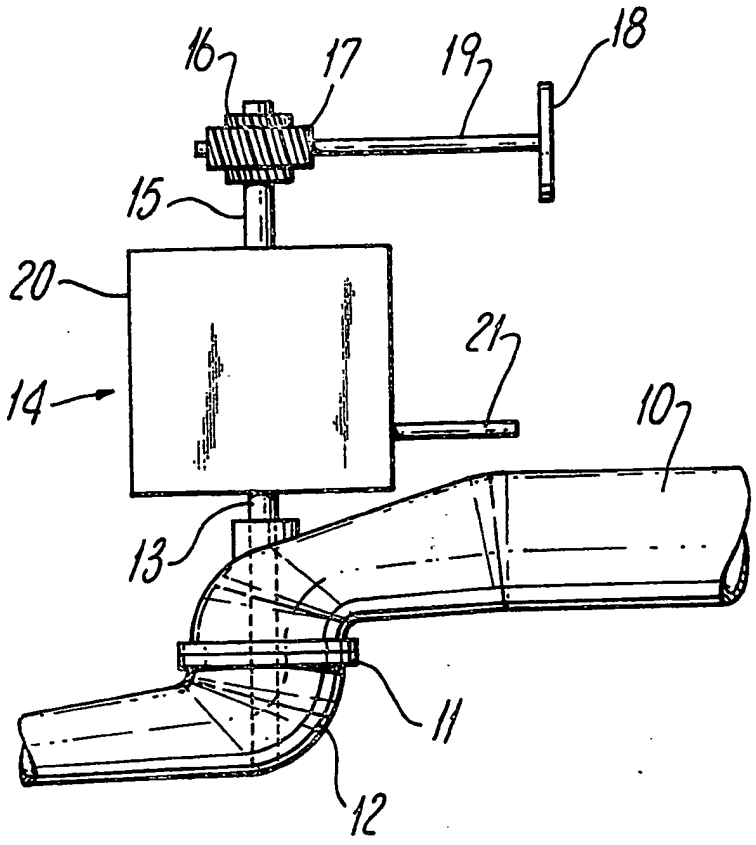

Fig.2.

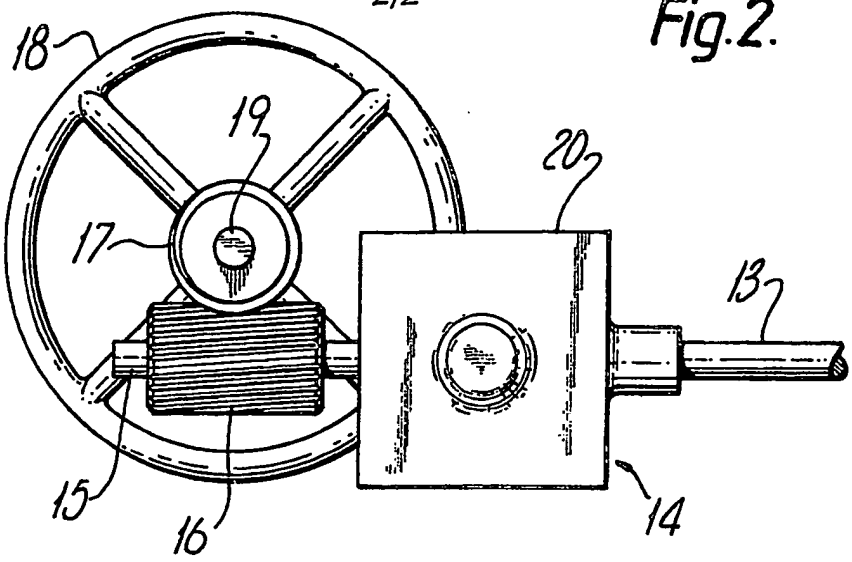
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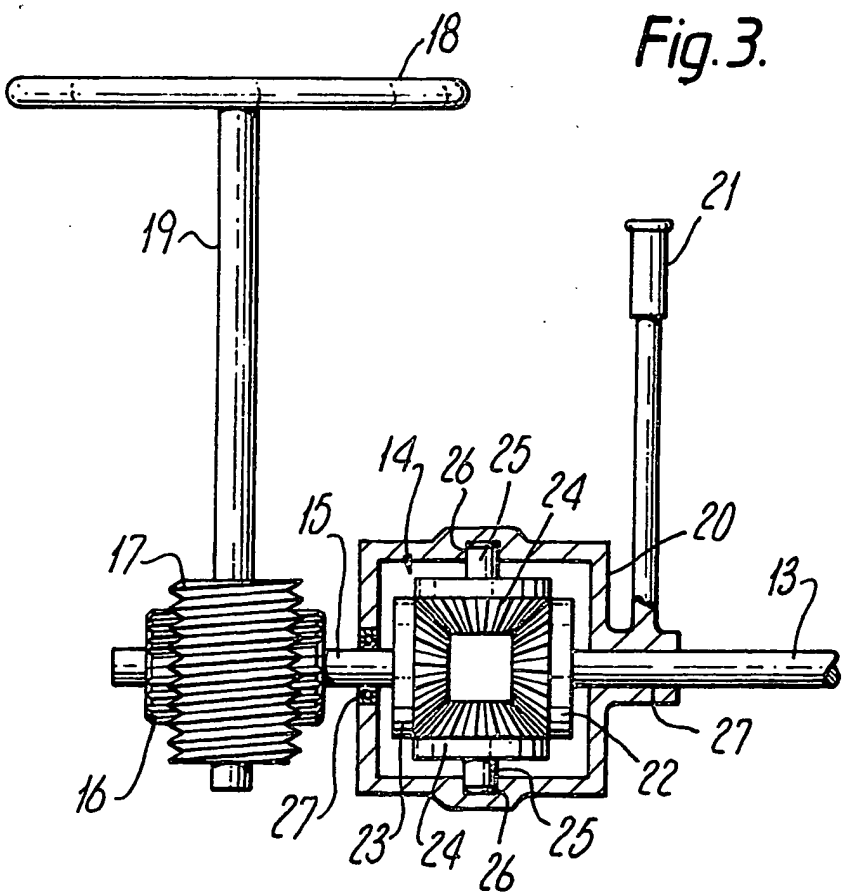
Fig.3.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SPECIFICATION

Water-jet steering mechanism

This invention relates to a steering mechanism for water-jet propelled craft, and more particularly to steering mechanisms for such craft equipped with rotatable propulsion nozzles.

Water-jet propelled craft are generally steered in one of two ways. The jet outlet itself may be fixed in direction, and the craft is steered and reversed by deflector surfaces which redirect the jet as described for example in United Kingdom Patent No 1396676. Alternatively, the jet may issue through a nozzle which is rotatable to redirect the jet and steer the craft, as set out for example in United Kingdom Patent No 1,253,814 (White). Of these alternatives, nozzle rotation provides more nearly equal propulsive thrust in the foward and reverse directions. This is an important feature in craft manoeuvrability, since the craft's sensitivity to its throttle control will vary undesirably if the propulsive thrust varies with jet direction. In comparison, the use of deflectors to steer and reverse jet thrust respectively results in maximum reverse thrust being appreciably less than forward thrust. However, against this the use of deflecters can provide independent steering and reversal controls, whereas rotatable nozzles necessarily have interdependent steering and reversal controls with consequent operating difficulties. United Kingdom Patent No 1,087,798 (Tamco) describes on Page 6, lines 70 onwards an arrangement providing separate steering and reversal controls operating through an epicyclic gearbox. However, lines 105 to 108 imply that considerable manual dexterity it required to operate the reversal control without affecting nozzle steering.

It is an object of the present invention to provide an improved steering mechanism for the rotatable nozzle of a water-jet propelled craft.

The present invention provides a steering-mechanism for a water-jet propelled craft having a rotatable propulsion nozzle, the mechanism including a fine steering control and a coarse reversal control each operative to rotate the nozzle, the reversal control being arranged to rotate the nozzle through 180 degrees, and means for inhibiting torque feedback from either control to the other. By inhibiting torque feedback between the controls in accordance with the invention, the interdependenc of the steering and reversal controls is reduced, the controls are easier to operate and the manoeuvrability of the craft is enhanced.

Torque feedback from the reversal control to the steering control may be inhibited by a worm and pinion reduction gear through which the steering control is arranged to rotate the nozzle. Torque feedback from the steering control to th rev rsal control may be inhibited, means may be provided to retain the reversal control in th forward or revers positions unless actuated therefrom. The reversal control may be hydraulic-ram actuated between forward and reverse positions, the ram allowing movement of the reversal control only when hydraulically actuated and being substantially unaffected by the steering control.

The controls may be arranged to operate through a common differential gearbox.

The reversal control may conveniently be interlocked with the water-jet propulsion system such that thrust of the system is reduced during movement of the reversal control into the forward or reverse positions.

In a preferred embodiment of the invention, the controls act via a common gearbox comprising a cage containing a differential arrangement of four bevel gears mounted on shafts each rotatable in a respective bearing retained by the cage, the steering control being operative via an input gearbox shaft and the reversal control being arranged to rotate the cage.

In order that the invention may be more fully understood, one embodiment thereof will now be described, by way of example only, with reference to the accompanying drawings, in which:–

Figure 1 shows schematically a steering mechanism of the invention coupled to a rotatable propulsion nozzle, and

Figures 2 and 3 respectively show plan and detailed part-sectional side views of a steering mechanism of the invention.

Referring to Figs. 1, 2 and 3, a water duct 10 is arranged to carry water from an impeller of a water-jet propulsion system (not shown). The duct 10 terminates in a mounting 11 connected to a nozzle 12 rotatable thereon in a horizontal plane. The nozzle 12 is rotatable by an output shaft 13 of a differential gearbox 14. The gearbox 14 has an input shaft 15 carrying a pinion 16 meshed with a worm gear 17. The worm and pinion arrangement effects a 12 to 1 reduction in rotation of the input shaft 15 by a steering or helm wheel 18 mounted on a steering shaft 19 connected to the worm gear 17. The gearbox 14 has a gear cage 20 to which a reversing lever 21 is rigidly attached.

The shafts 13 and 15 are coaxial and terminate in respective output and input bevel gears 22 and 23. Two intermediate bevel gears 24 each mesh with the output bevel gears 22 and 23 in a conventional differential gear arrangement, the bevel gears 22, 23 and 24 being of like dimensions. The intermediate bevel gears 24 are mounted on stub axles 25 rotatable on bearings 26 set in the gear cage 20. The input and output shafts pass within the gear cage 20 through journal bearings 27.

The arrangement of Figs 1 t 3 operates as follows.

Wh n the input shaft 15 rotates, input bevel gear 23 rotates the gears 24, which then drive the utput bevel gear 22 and output shaft 13 in the opposite direction to that of the input shaft 15. The output and input bevel gears 22 and 23 are equal in size and numbers of teeth, so that rotation of the output and input shafts is at the same rate. When the reversing lever 21 is moved through an arc in a plane perpendicular to the shafts 13 and 15 with the helm wheel 18 stationary, the gear cage 20 rotates on the nearings 27 carrying with it the stub axles 25, and the gears 24 roll on the input bevel gear 23.

To accomodate rotation of the axles 25 and rolling of the gears 24, the output bevel gear 22 and shaft 13 rotate through trice the angle through which the reversing lever 21 is moved. The lever 21 ia arranged for a 90° travel between forward and reverse endpoints (not shown) corresponding to 180° of nozzle rotation. The action of the differential gearbox gears up nozzle rotation by the reversing lever rotation by a factor of 2 compared to nozzle rotation by the input shaft 15. The reversing lever 21 is accordingly a coarse control of nozzle rotation.

By the reduction arrangement of the worm gear 17 and pinion 16, nozzle rotation by the helm wheel 18 is geared down by a factor of 12, and is therefore geared down by a factor of 24 as compared in the reversing lever 21. The helm wheel 18 accordingly acts as a fine control of rotation of the nozzle 12.

In addition to increasing the reduction in gearing of the helm wheel 18 compared to the reversing lever 21 the use of a worm and pinion arrangement has the additional property of irreversibility. It is well-known in mechanical engineering that a sufficiently high reduction worm and pinion combination will transmit torque from the worm to the pinion but not vice versa. The gear ratio at which irreversability occurs depends on the angle of friction between the worm and pinion, and the 12 to 1 ratio employed is in excess of the required minimum for all common lubricant/-metal gear combinations. Accordingly, operation of the reversing lever 21 does not transmit a torque reaction feedback to the helm wheel 18. To inhibit torque reaction in the opposite direction, ie rotation of the helm wheel producing a tendency to rotate the g ar cag 20 and lever 21, locking means (not shown) are provided to lock the rev rsing lever 21 at ither end of its 90° travel. This may be implemented by a hydraulic ram actuator coupled to th lever 21, and operative to move the lever between the forward and reverse positions whilst being insensitive to operation of the st ering control or helm wheel 18.

An interlock (not sh wn) is provided betw en the r v rsing lever and the water jet propulsion system so that power is throttled back whilst the reversing l ver is in a position intermediat forward and reverse. The interlock reduces lateral thrust on the craft when the nozzle is directed abeam during actuation of the reversing control.

Conveniently, the differential gearbox 14 may be provided with means such as shims or spring-loaded gears for reducing backlash.

The invention may incorporate other means for inhibiting torque feedback between the steering and reversal controls. The example of the invention described with reference to Figs. 1, 2 and 3 incorporates direct mechanical actuation of nozzle rotation, but indirect actuation by hydraulic or electric means may be employed and this may facilitate torque feedback reduction.

Differential operation of the steering and reversal controls may alternatively be achieved without a common differential gearbox, the controls being actuated by motor drive means operative at differential rates. The drive would be adapted to inhibit torque feedback between the controls.

In the arrangement of Fig. 1, the helm wheel 18 is shown located comparatively close to the nozzle 12. It may be more convenient in some craft for the helm wheel to be located remotely from the nozzle. If this is required the input shaft 15 or the steering shaft 19 may be remotely actuated via various known means such as servomechanisms, hydraulic actuators or cables.

The present invention has the advantage that while prior art buckets or scoops for water-jet reversal are not required, independent operation of the steering and reversal controls is preserved. This makes it possible to position a water craft accurately by alternate forward and reverse motion with the nozzle spending a reduced time period directed beam of the craft and without cumbersome manipulation of interdependent controls.

This reduces the lateral displacement of the craft during such positioning and a further reduction is achieved by throttle/reverse control interlock. The forward and reverse thrusts are substantially equal, apart from minor differences introduced by the hull of the craft affecting the jet differently in the forward and reverse positions. Prior art deflector surfaces have the effect of reducing the reverse thrust considerably, so that speed in rev rse is reduced and positi ning sensitivity varies between the forward and reverse directions.

CLAIMS

1. A steering mechanism for a water-jet propelled craft having a rotatable propulsion nozzle, the mechanism including a fine steering control and a coarse reversal control each operative to r tate the nozzle, the reversal

c ntrol being arranged to rotate the nozzle through 180 degrees, and means for inhibiting torque feedback from either contr l to the other.

2. A steering mechanism according to claim 1 including a worm and pinion reduction gear arranged to inhibit torque feedback fr m the reversal control to the steeering control, the steering control being arranged to rotate the nozzle through the reduction gear.

3. A steering mechanism according to claim 1 or 2 including a hydraulic reversal control actuating ram arranged to inhibit torque feedback to the reversal control from the steering control, the ram being unresponsive to steering control operation.

4. A steering mechanism according to claim 1, 2 or 3 wherein the steering and reversal controls are arranged for nozzle rotation via a common differential gearbox.

5. A steering mechanism according to claim 4 wherein the gearbox comprises a cage containing a differential arrangement of four bevel gears rotatable in bearings retained by the cage.

6. A steering mechanism according to claim 5 wherein the steering control is operative to rotate the bevel gears within the cage via a gearbox input shaft and the reversal control is operative to rotate the cage.

7. A steering mechanism substantially as herein described and as illustrated in the accompanying Figs. 1, 2 and 3.

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